

WHAT IS CLAIMED IS:

1. A film forming apparatus comprising:  
a silicon film forming vacuum chamber for forming a  
crystalline silicon film on a substrate;  
5        a film forming device provided for said vacuum chamber  
for forming a pre-film of the crystalline silicon film on a  
target surface of said substrate; and  
an energy beam irradiating device provided for said  
vacuum chamber for irradiating said pre-film with an energy  
10 beam for crystallizing said pre-film.

2. The film forming apparatus according to claim 1,  
wherein

15        said film forming device can form said pre-film over a  
length, in a first direction, of the target surface of said  
substrate, said energy beam irradiation device can irradiate  
the target surface of said substrate over the length in the  
first direction with the energy beam, and a substrate  
transporting device is arranged in said silicon film forming  
20 vacuum chamber for moving said substrate in a second direction  
crossing said first direction of the target surface.

3. The film forming apparatus according to claim 1,  
wherein

25        said film forming device includes an ion source for  
emitting an ion beam to the substrate.

4. The film forming apparatus according to claim 3,  
wherein

said ion source can emit the ion beam with an emission  
5 energy of about 100 ev to about 10 kev.

5. The film forming apparatus according to claim 2,  
wherein

said film forming device includes an ion source for  
10 emitting an ion beam to the substrate.

6. The film forming apparatus according to claim 5,  
wherein

said ion source can emit the ion beam with an emission  
15 energy of about 100 ev to about 10 kev.

7. The film forming apparatus according to claim 1,  
wherein

an electrical insulating film forming vacuum chamber for  
20 forming an electrical insulating film on the target surface of  
said substrate is connected to said silicon film forming vacuum  
chamber via a connection hermetically sealed against an  
external.

25 8. The film forming apparatus according to claim 3,  
wherein

an electrical insulating film forming vacuum chamber for  
forming an electrical insulating film on the target surface of  
said substrate is connected to said silicon film forming vacuum  
chamber via a connection hermetically sealed against an  
external.

9. The film forming apparatus according to claim 5,  
wherein

an electrical insulating film forming vacuum chamber for  
10 forming an electrical insulating film on the target surface of  
said substrate is connected to said silicon film forming vacuum  
chamber via a connection hermetically sealed against an  
external.

15 10. The film forming apparatus according to claim 1,  
wherein

a preheating vacuum chamber for preheating the substrate  
before the film formation is connected to said silicon film  
forming vacuum chamber via a connection hermetically sealed  
20 against an exterior.

11. The film forming apparatus according to claim 1,  
wherein

a preliminary vacuum chamber allowing external  
25 transportation of the substrate is connected to said silicon  
film forming vacuum chamber via a connection hermetically

~~sealed against an exterior.~~

12. The film forming apparatus according to claim 10,  
wherein

5        a preliminary vacuum chamber allowing external  
transportation of the substrate is connected to said silicon  
film forming vacuum chamber via a connection hermetically  
sealed against an exterior.

10        13. The film forming apparatus according to claim 7,  
wherein

a preheating vacuum chamber for preheating the substrate  
before the film formation is connected to said silicon film  
forming vacuum chamber via a connection hermetically sealed  
15 against an exterior; and

a preliminary vacuum chamber allowing external  
transportation of the substrate is connected to said silicon  
film forming vacuum chamber via a connection hermetically  
sealed against an exterior.

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14. The film forming apparatus according to claim 8,  
wherein

a preheating vacuum chamber for preheating the substrate  
before the film formation is connected to said silicon film  
25 forming vacuum chamber via a connection hermetically sealed  
against an exterior; and

a preliminary vacuum chamber allowing external transportation of the substrate is connected to said silicon film forming vacuum chamber via a connection hermetically sealed against an exterior.

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15. The film forming apparatus according to claim 9, wherein

a preheating vacuum chamber for preheating the substrate before the film formation is connected to said silicon film 10 forming vacuum chamber via a connection hermetically sealed against an exterior; and

a preliminary vacuum chamber allowing external transportation of the substrate is connected to said silicon film forming vacuum chamber via a connection hermetically 15 sealed against an exterior.

*S, B* 16. A crystalline silicon film forming method comprising the steps of:

preparing a film forming apparatus having a silicon film 20 forming vacuum chamber for forming a crystalline silicon film on a substrate, and provided with a film forming device for forming a pre-film of the crystalline silicon film on a target surface of said substrate, and an energy beam irradiating device for irradiating said pre-film with an energy beam for 25 crystallizing said pre-film;

locating the substrate in said silicon film forming

vacuum chamber, and forming the pre-film of the crystalline silicon film on the target surface of said substrate by said film forming device; and

producing the intended crystalline silicon film from said 5 pre-film by irradiating said pre-film in said vacuum chamber with said energy beam for crystallization of said pre-film emitted from said energy beam irradiating device subsequently to the formation of said pre-film.

10        17. The crystalline silicon film forming method according to claim 16, wherein

      said film forming device employs such a structure that can form said pre-film over a length, in a first direction, of the target surface of said substrate, said energy beam 15 irradiation device employs such a structure that can irradiate the target surface of said substrate over the length in the first direction with the energy beam, and the intended crystalline silicon film can be successively formed by operating said film forming device to form said pre-film in 20 said first direction on the target surface of said substrate, and concurrently operating said energy beam irradiation device to irradiate the formed pre-film with the energy beam while moving said substrate in a second direction crossing said first direction.

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18. The crystalline silicon film forming method according

to claim 16, wherein

10        said silicon film forming vacuum chamber is further provided with an ion source, and said pre-film of the crystalline silicon film is formed on said target surface while emitting an ion beam to the target surface of said substrate in said step of forming said pre-film by said film forming device.

15        19. The crystalline silicon film forming method according to claim 17, wherein

20        10        said silicon film forming vacuum chamber is further provided with an ion source, and said pre-film of the crystalline silicon film is formed on said target surface while emitting an ion beam to the target surface of said substrate in said step of forming said pre-film by said film forming device.

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20        20. The crystalline silicon film forming method according to claim 16, wherein

25        said silicon film forming vacuum chamber is further provided with an ion source, an ion beam is emitted to the target surface of said substrate from said ion source prior to said step of forming said pre-film by said film forming device, and said pre-film is formed on said target surface irradiated with the ion beam.

30        25        21. The crystalline silicon film forming method according to claim 17, wherein

5 said silicon film forming vacuum chamber is further  
provided with an ion source, an ion beam is emitted to the  
target surface of said substrate from said ion source prior to  
said step of forming said pre-film by said film forming device,  
and said pre-film is formed on said target surface irradiated  
with the ion beam.

10 22. The crystalline silicon film forming method according  
to claim 16, wherein

15 said silicon film forming vacuum chamber is further  
provided with an ion source, and an ion beam is emitted to the  
target surface of said substrate from said ion source in an  
initial stage of said step of forming said pre-film by said  
film forming device.

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23. The crystalline silicon film forming method according  
to claim 17, wherein

25 said silicon film forming vacuum chamber is further  
provided with an ion source, and an ion beam is emitted to the  
target surface of said substrate from said ion source in an  
initial stage of said step of forming said pre-film by said  
film forming device.

30 24. The crystalline silicon film forming method according  
to claim 16, wherein

35 said silicon film forming vacuum chamber is further

provided with an ion source, and an ion beam is emitted to the target surface of said substrate from said ion source during a period from a stage before said pre-film forming step of forming said pre-film by said film forming device to an initial 5 stage of said pre-film forming step.

25. The crystalline silicon film forming method according to claim 17, wherein

said silicon film forming vacuum chamber is further 10 provided with an ion source, and an ion beam is emitted to the target surface of said substrate from said ion source during a period from a stage before said pre-film forming step of forming said pre-film by said film forming device to an initial stage of said pre-film forming step.

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26. The crystalline silicon film forming method according to claim 18, wherein

an emission energy of said ion beam is in a range from 100 eV to 1 keV.

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27. The crystalline silicon film forming method according to claim 20, wherein

an emission energy of said ion beam is in a range from 500 eV to 10 keV.

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28. The crystalline silicon film forming method according

to claim 22, wherein

an emission energy of said ion beam is in a range from 500 eV to 10 keV.

5        29. The crystalline silicon film forming method according to claim 22, wherein

an emission energy of said ion beam is in a range from 2 keV to 10 keV.

*Sub B* 10        30. The crystalline silicon film forming method according to claim 25, wherein

an emission energy of said ion beam is in a range from 500 keV to 10 keV.

15        31. The crystalline silicon film forming method according to claim 18, wherein

said film forming device employs a structure performing the film formation by plasma CVD.

20        32. The crystalline silicon film forming method according to claim 31, wherein

the formation of the pre-film by said plasma CVD uses a mixture gas of a silicon-contained gas and a hydrogen gas as a gas for film formation.